



**Centres de Compétence Technique**

**CCT SCA – Systèmes de Commande  
et Automatique**



## Séminaire

# Inversion dynamique non linéaire (NLDI) appliquée aux systèmes aérospatiaux

**Mardi 16 mars 2010  
(9h15-12h30)**

Institut Aéronautique et Spatial (IAS)  
23 Avenue Edouard Belin, 31028 Toulouse, cedex 4

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*Ce séminaire propose après un bref rappel sur le principe de l'inversion dynamique non linéaire un rapide tour d'horizon de l'application de l'inversion dynamique non linéaire aux systèmes aéronautiques et spatiaux. Au travers d'un échantillon d'applications (trajectoire de montée d'un lanceur, détection de défaut sur avion, génération de trajectoire de rentrée), on abordera la démarche générique, les limitations rencontrées et les résultats obtenus en simulation et lors de test expérimentaux..*

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<http://cnes.cborg.net/cct/bipublic.html>

## Programme

**09h15-09h30**

**Accueil**

**09h30-10h15**

**Introduction to NDI concept and applications to aircraft control law (military: X-31 and civil transport)**

Gertjan Looye (DLR Germany)

**10h15-10h45**

**NDI and Constrained Control Allocation - An Application to Civil Transport Aircraft**

Bing Dang Vu (ONERA Salon de Provence)

A significant work has been published using non-linear dynamic inversion methods as an approach to design flight control laws. The methodology is based upon straightforward manipulations of the equations of flight mechanics from which state-dependent forces and moments for the control to generate can be specified. The last step in dynamic inversion is to solve for the control vector which is constrained to certain limits. This is referred to as constrained control allocation. Research into the problem of allocating flight control effectors to generate specified moments has explored techniques that achieve the maximum attainable aircraft moment. The contribution of this presentation is to incorporate control allocators obtained from such techniques inside a closed-loop dynamic inversion control law. The combined approach is used to design the reconfigured flight control law of a transport aircraft following severe actuator failures leading to aircraft states close to the limits of the flight envelope.

**10h45-11h00**

**Pause**

**11h00-11h30**

**The use of Adaptive Nonlinear Dynamic Inversion for Fault Tolerant Flight Control, application to civil aircraft**

Thomas Lombaert (TU Delft NL)

This presentation will discuss a study on fault tolerant flight control of a benchmark civil aircraft model. Reconfiguring control is implemented by making use of adaptive nonlinear dynamic inversion for manual and autopilot control. The weakness of classical nonlinear dynamic inversion, its sensitivity to modeling errors, is circumvented here by making use of a real-time identified physical model of the damaged aircraft. With help of a high fidelity Boeing 747 benchmark simulation model, including realistic component as well as structural failure modes, it is possible to analyze the damage accommodation capabilities of the considered approach. In failure conditions,



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the damaged aircraft model is identified in real time by the two-step method and this model is applied subsequently to the model-based adaptive nonlinear dynamic inversion routine in a modular structure, which allows flight control reconfigurations online. After discussing the modular adaptive controller setup, reconfiguration test results are shown for damaged aircraft models using a desktop computer for autopilot control as well as the moving base Simulation, Motion, and Navigation (SIMONA) Research Flight Simulator of Delft University for manual control. These results indicate satisfactory failure handling capabilities of this fault tolerant control setup, for component as well as structural failures.

**11h30-12h00**

**Optimisation par inversion dynamique, application au phase d'ascension lanceur lourd, et réentrée sous contrainte thermique**

Nicolas Petit (CAS Mines ParisTech)

**12h00-12h30**

**Inversion Dynamique Robuste Appliquée à la Rentrée Atmosphérique.**

Mario Hernandez (ou Franck Jouhaud à confirmer). (CERT/ONERA)